The sidewalk, safety curb or barrier sections may be cast after the curtain walls and exterior pier keeper blocks have been cast. In this case, the curtain walls and keeper blocks shall be accurately formed above the beams to the shape and dimensions of the coping, including the thickness of the closed cell foam, as shown on the plans. Closed cell foam will be attached to the curtain wall/keeper block prior to placing the coping concrete.

930.63 Prestressed I-Beam, Bulb Tee, and Spread Box Beam Sections.

Anchor bolts, where called for on the plans, shall be set as follows: in piers, anchor bolts shall be accurately set by template prior to placing concrete; in abutments, anchor bolts may be set by template or by drilling and grouting. Grout shall be a non-shrink type.

Keeper blocks on the abutments and pier caps, where called for on the plans, shall be cast after the beams have been erected. Closed cell foam of the thickness shown on the plans shall be attached to sides of the beam within the limits of the keeper blocks prior to placing the concrete.

As beams are being erected, temporary blocking or bracing shall be installed at the ends of the beams to prevent the beams from accidentally rotating and tipping over. The detail for this bracing shall be included with the erection procedure submittal.

After the reinforced concrete diaphragms have been poured and allowed to reach a minimum of 70% of the required 28 day strength, the temporary bracing may be removed. In addition, the placement of the deck concrete will not be permitted until these concrete diaphragms have been installed and have reached this minimum strength.

The top of the beam shall be clean, free of all laitance and shall have a rough surface raked across the width of the beam. Deck concrete shall be placed against the beam concrete without the use of any bonding agents.

COMPENSATION

930.81 Basis of Payment.

The above work shall be paid for at the contract lump sum price under the respective items of Prestressed Concrete Deck Beams, Prestressed Concrete Beams (I or Bulb Section), and Prestressed Concrete Box Beams complete in place and accepted.

930.82 Payment Items.

930.	Prestressed Concrete Deck Beams	Lump Sum
930.1	Prestressed Concrete Box Beams	Lump Sum
931.	Prestressed Concrete Beams (I or Bulb Section)	Lump Sum
932.	Elastomeric Bridge Bearing Pad	Square Meter
933.	Elastomeric Bridge Bearing Pad	Each

SECTION 940

DRIVEN PILES

DESCRIPTION

940.20 General.

This work shall consist of furnishing and driving piles to the required bearing capacity in accordance with these specifications and in close conformity with the lines and grades shown on the plans established by the Engineer.

The Contractor will be responsible for furnishing piling of sufficient length to obtain the penetration and bearing value required.

940.21 Pile Schedule.

The Contractor shall submit to the Engineer, for approval, a schedule of the length of piles he/she proposes to order, and the schedule shall designate the respective location of the piles. The scheduled length shall comprise the length expected to be left in the structure plus the length that might be necessary to provide fresh heading. When test piles and load tests are required, the data obtained from driving test piles and making test loads shall be used in conjunction with other available information to determine the lengths of piles to be furnished.

940.22 Precast-Prestressed Concrete Piles.

A. Required Submittals.

The Contractor shall submit to the Engineer shop drawings and design calculations which demonstrate the pile complies with the Contract documents. The drawings shall include a schedule of pile lengths, all structural, reinforcing and prestressing details, pickup points, and splice designs. All designs shall be in accordance with the latest AASHTO "Standard Specifications for Highway Bridges."

B. Special Tips.

Piles driven to bed rock, into dense stratum or through strata with obstructions shall be equipped with embedded steel H sections or equivalent type protection to minimize damage to the pile tip.

C. Extensions.

Extensions on precast-prestressed piles shall be in accordance with details shown in the Contract Documents. The final cutting shall be perpendicular to the axis of pile at such an elevation that at least
40 diameters of reinforcing steel are exposed. The final cutting shall not cause undue spalling of the pile adjacent to the cut. Steel reinforcing and concrete for the extensions shall be of the same strength and quality as that used for the original pile.

MATERIALS

940.40 General.

A. Piles shall meet the requirements specified in the following Subsections of Division III, Materials:

Untreated Timber Pile	M9.05.6
Treated Timber Pile	M9.05.6
Steel Pile	M8.05.1
Steel Pipe Piles	M8.05.5
Cast-in-Place Pile	M8.05.2
Precast-Prestressed Concrete Pile	M8.05.6
30 MPa - 20 mm - 390 kg Cement Concrete	M4.02.00
Steel Reinforcement	M8.01.0
Mortar	M4.02.15

B. Length of Steel Pipe and H Piles.

When the proposed length is:

1. 20 meters or less, the pile shall be furnished in a single piece of the required length.
2. Greater than 20 meters, the Contractor will have the option of furnishing the pile in a single piece, or of furnishing each pile in 2 pieces, approximately equal in length, to make up the required length.
3. 30 meters or less, piles shall be spliced on the ground before being placed in the leads.

C. Length of Precast-Prestressed Concrete Piles.

1. 20 meters or less the pile shall be furnished in a single piece.
2. Greater than 20 meters, the Contractor shall have the option of furnishing the pile in a single piece or splicing 2 pieces approximately equal in length.

D. Storage and Handling of Piles.

Special care shall be used in the storage and handling of piles to avoid damage.

The method of handling of precast-prestressed concrete piling shall prevent cracking or fracture by impact or induced bending stresses. At the discretion of the Engineer, cracked or fractured piling shall be either rejected or repaired with epoxy. Fine cracks, which do not extend to the reinforcing steel as determined by the Engineer, will neither require repair or be cause for rejection. The Contractor's proposed method for repair with epoxy or the like shall be submitted to the Engineer for approval.

E. Pile Shoes and Tips.

Pile shoes of the type and dimensions specified shall be provided and installed when shown on the contract documents.

Timber pile shoes shall be metal and be fastened securely to the pile. Timber pile tips shall be carefully shaped to secure an even uniform bearing on the pile shoes.

Steel pile shoes shall be fabricated from cast steel conforming to ASTM A 27 or A 377.

CONSTRUCTION METHODS

940.50 Equipment for Driving Piles.

940.51 Hammers.

A. General.

Piles shall be driven by approved power hammers or by a combination of jetting and power hammers. Power hammers include single, double and differential acting air or steam hammers, and open or closed-end diesel hammers. Drop (Gravity) hammers may be used with the written permission of the Engineer to drive timber piles.

Valve mechanisms and other parts of power hammers shall be maintained in good condition. Hammers shall be capable of delivering the manufacturer's rated energy and shall be operated at the manufacturer's specified maximum blows per minute. Power sources such as steam boilers and air compressors shall be capable of continuously maintaining the hammer manufacture's recommended pressure and flow rate at the intake of the hammer. Boilers and Compressors shall be equipped with pressure gauges or other devices, calibrated against the rated hammer energy. When directed by the Engineer, a gauge readable from the ground surface shall be provided at the hammer intake to determine the actual pressure delivered to the hammer.

The Contractor shall equip open-end diesel hammers with a calibrated scale to enable accurate observation of ram stroke from the ground surface.

The Contractor shall also provide the Engineer a chart from the hammer manufacturer equating stroke and blows per minute for the open-end diesel hammer to be used.

Double acting diesel hammers (closed-end) shall be equipped with a gauge to measure pressure in the bounce chamber. The gauge shall be readable from the ground surface. Alternatively the gauge can be equipped with a hose sufficiently long to enable reading on the ground surface. The gauge and hose assembly shall be calibrated to allow for losses in the hose. The Contractor shall provide charts relating the throttle setting and/or bounce chamber pressure to rated hammer energy.

B. Minimum Energy Requirements.

Power Hammers shall have a ram mass of not less than 900 kilograms and shall develop not less than 8000 joules of energy per blow. When driving to final resistance, the total energy in joules to drive the pile the last 150 millimeters shall not exceed 1700 times the pile tip diameter in millimeters.

Drop (Gravity) Hammers may be used only with the written permission of the Engineer. Such hammers shall have a mass of between 900 and 1600 kilograms, but in no case shall the mass of the hammer be less than the combined mass of driving head and pile. The fall shall be so regulated as to avoid damage to the pile and in no case shall exceed 4.5 meters.

To control excessive stress in concrete piling during driving, the Engineer may require:

1. Increase in cushion thickness, or change the materials comprising the cushion,
2. Reduction of ram stroke,
3. Reduced ram stroke for driving through very soft soil and increased ram stroke as soil resistance increases,
4. Combination of increased cushion thickness and reduced ram stroke,
5. Combination of increased cushion thickness and shorter stroke, or
6. Use of pilot holes or jetting when driving through hard or alternating hard and soft strata.

C. Submittals.

The Contractor shall submit to the Engineer for approval, a description of the proposed driving equipment with manufacturer's specifications. The equipment description shall include hammer type, hammer cushion, drivehead, and pile cushion, etc. as contained in the "Pile and Driving Equipment Data Form" included in the contract documents or supplied by the Engineer.

D. Approval Criteria.

Power hammers shall have an energy rating that will provide the required pile capacity with a penetration resistance between 20 and 50 blows per 100 millimeters. The energy required for these rates shall be determined by the formula given in Section 940.61A for piles with a required capacity less than 450 kiloNewtons. For piles with required capacity over 450 kiloNewtons, or as directed by the Engineer, the Contractor shall submit to the Engineer the results of a Wave Equation Analysis performed in accordance with Section 940.61B for the proposed driving equipment. The analysis shall evaluate the acceptability of the driving equipment with regard to energy transfer to the pile top and the potential for impending pile damage due to induced driving stresses.

The pile stresses which are indicated by the wave equation to be generated by the driving equipment shall not exceed the values where pile damage impends, if the equipment is to be acceptable. That value is determined by the magnitude of the induced compressive stresses.

The point of impending damage in steel piles is defined herein as a compressive driving stress of 90 percent of the yield point of the pile material. For concrete piles, tensile stresses using units of kiloPascals shall not exceed 7.8 multiplied by the square root of the concrete compressive strength, f'_c, in kiloPascals plus the effective prestress value $[7.8(f'_c)^{0.5}$ + prestress] and compressive stresses shall not exceed 85 percent of the compressive strength minus the effective prestress value ($0.85\ f'_c$ – prestress). For timber piles, the compressive driving stress shall not exceed three times the allowable static design strength listed on the plans. These criteria will be used in evaluating wave equation results to determine acceptability of the Contractor's proposed driving system. The results of the analysis, including input parameters, shall be subject to the review and approval of the Engineer prior to any pile installations.

The Contractor will be notified of the acceptance or rejection of the driving system within 14 calendar days of the Engineer's receipt of the "Pile and Driving Equipment Data Form." If the wave equation analyses show that either pile damage or inability to drive the pile with a reasonable blow count to the desired ultimate capacity will result from the Contractor's proposed equipment or methods, the Contractor shall modify or replace the proposed methods or equipment until subsequent wave equation analyses indicate the piles can be reasonably driven to the desired ultimate capacity, without damage.

Approval of the equipment by the Engineer will not relieve the Contractor of his/her responsibility to provide and install piles capable of supporting the design loads given on the contract documents.

940.52 Driving Appurtenances.

A. Pile Drive Head.

Pile driven with impact hammers require an adequate drive head to distribute the hammer blow to the pile head. The drive head shall be axially aligned with the hammer and the pile. The drive head should be guided by the leads and not be free-swinging. The drive head should fit around the pile head in such a manner as to prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

1. For steel and timber piling, the pile heads shall be cut squarely and a drive head, as recommended by the hammer manufacturer, be provided to hold the axis of the pile in line with the axis of the hammer.
2. For precast concrete and prestressed concrete piles, the pile head shall be plane and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts.
3. For special types of piles, appropriate driving heads, mandrels or other devices shall be provided in accordance with the manufacturer's recommendations so that the piles may be driven without damage.

B. Bands.

Collars, bands, or other devices to protect timber piles against splitting and brooming shall be provided by the Contractor.

C. Hammer Cushion.

All pile driving equipment shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to insure uniform driving behavior. Hammer cushions shall be made of durable, manufactured materials, provided in accordance with the hammer manufacturer's guidelines except that all wood, wire rope, and asbestos hammer cushions are specifically disallowed and shall not be used. A striker plate as recommended by the hammer manufacturer shall be placed on the hammer cushion to insure uniform compression of the cushion material.

The hammer cushion shall be inspected in the presence of the Engineer when beginning pile driving at each substructure element or after each 100 hours of pile driving, whichever is less. Any reduction of hammer cushion thickness shall be replaced by the Contractor before driving is permitted to continue.

D. Pile Cushion.

The heads of concrete piles shall be protected by a pile cushion made of plywood or other similar material approved by the Engineer. The minimum plywood thickness placed on the pile head prior to driving shall not be less than 100 millimeters. A new pile cushion shall be provided for each pile. In addition during the driving of each pile, the pile cushion shall be replaced if during the driving the cushion is either compressed more than one-half the original thickness or begins to burn. The pile cushion dimensions shall match the cross-sectional area of the pile top.

E. Leads.

The pile driver shall be equipped with fixed leads that are an integral part of the machine. The pile driving hammer shall ride in the ways of the leads. Fixed leads shall be used for driving all piles unless written approval to the contrary is obtained from the Engineer.

F. Followers.

Followers shall only be used when approved in writing by the Engineer, or when specifically stated in the contract documents. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full length piles. The final position and alignment of the first two piles installed with followers in each substructure unit shall be verified to be in accordance with the location tolerances in this specification before additional piles are installed.

G. Jets.

Jetting shall only be permitted if approved in writing by the Engineer or when specifically stated in the contract documents.

Jetting will not be allowed when driving through newly placed embankment.

The use of water jets will be permitted only when excess of water will not affect adjacent structures. In general, jetting will not be permitted near railroad tracks.

When jetting is permitted, the Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. The Contractor shall control, treat if necessary, and dispose of all jet water such as to meet environmental considerations. The Contractor shall be responsible for all damage to the site caused by jetting operations. The jetting plant shall have sufficient capacity to deliver at all times a pressure equivalent to at least 700 kiloPascals at two 20 millimeter jet nozzles. Unless otherwise indicated, jet pipes shall be removed when the pile tip is a minimum of 1.5 meters above prescribed tip elevation and the pile shall be driven to the required bearing capacity with an impact hammer.

H. Preaugering.

Preaugering shall only be permitted if approved in writing by the Engineer or when specifically stated in the Contract documents. When permitted, the Contractor shall provide the necessary equipment such as augers, well drilling machines, etc. to preauger holes at pile locations and to the depths required by the Engineer.

PILE INSTALLATION

940.60 Preparation for Driving.

A. Excavation.

When piles are located in an area where excavation is to be made or in an area where embankment is to be placed, the piles shall not be driven until the excavation has been made or the embankment has been placed. For either of the foregoing, the grade shall be brought to such an elevation as to compensate for possible uplift or subsidence of the surrounding earth. Adjustments in the grade shall be made after all the piles at the location have been driven. Additional excavation or embankment will be considered as part of the process of pile driving and will not be included in the payment for either excavation or borrow.

B. Preaugering.

Where timber, cast-in place, precast-prestressed concrete piles, or steel piles are to be driven through an embankment, and the depth of the embankment at the pile location is in excess of 1.5 meters, the Contractor shall make a hole for the full depth of the embankment for each pile with an auger or by other approved methods. The hole shall have a diameter of not less than the butt diameter of the pile. After driving, the annular space around the pile shall be filled to the ground surface with dry sand, fine gravel or pea stone. Material resulting from drilling holes shall be disposed of in accordance with Section 120, Excavation.

940.61 Driven Pile Capacity.

For piles with proposed capacities greater than 450 kiloNewtons, the safe bearing values shall be determined by a Wave Equation Analysis conducted by a Registered Professional Engineer experienced in the method of analysis, at the expense of the Contractor. For piles with proposed capacities not greater than 450 kiloNewtons, the safe bearing values may be determined by the following formula unless directed otherwise by the Engineer.

A. Formula Method.

$$R_u = 211\,(E)^{0.5} \log(10N) - 127(E)^{0.5} - 440$$

Where:

R_u = Ultimate Pile Capacity (kiloNewtons)
E = Manufacturer's rated energy of the hammer, at stroke observed in field, in kilojoules.
Log (10N) = Logarithm to the base 10 of the quantity "10" multiplied by N, the number of hammer blows per 100 millimeters at final penetration (blows per 100 millimeters).

The above formula is applicable only when:

(a) A follower is not used.

(b) The hammer is operated within the range established by the manufacturer.

A design safety factor of 3.5 is to be used when using this formula to determine the safe design load, i.e., if a design load of 450 kiloNewtons is required in the bearing layer, then an ultimate capacity of 1575 kiloNewtons should be used in the formula to determine the necessary hammer blow count.

The above formula may be modified by the Engineer if he/she deems it necessary on the basis of information obtained from a loading test or dynamic field measurements during pile driving.

B. Wave Equation Method.

When required in the contract documents, the ultimate pile resistance shall be determined by the Engineer based on a wave equation analysis. Piles shall be driven with the approved driving equipment to the ordered length or other lengths necessary to obtain the required ultimate pile resistance. Jetting, pre-augering or other methods to facilitate pile penetration shall not be used unless specifically permitted either in the contract documents or approved by the Engineer after a revised driving resistance is established from the wave equation analysis. Adequate pile penetration shall be considered to be obtained when the specified wave equation resistance criteria is achieved within 1.5 meters of the tip elevation based on ordered length. Piles not achieving the specified resistance within these limits shall be driven to penetrations established by the Engineer.

The Contractor is required to perform a wave equation analysis upon each pile type, each pile size, at each significant variation in soil profile, and at each pile driven for the static load test as shown on the plans. When dynamic load tests are required then a wave equation analysis must be performed for each pile to be dynamic load tested by the "Pile Driving Analyzer" (PDA) as determined by the Engineer. The wave equation analysis shall be made as outlined in the latest edition of the FHWA publication entitled "Manual on Design and Construction of Driven Pile Foundations."

If more than one driving system is proposed by the Contractor, a wave equation analysis shall also be made for each driving system. The driving system, as detailed on the "Pile Driving and Equipment Data Form," shall be completed by the Contractor and furnished for use as wave equation input data.

No change in driving equipment will be permitted after an evaluation by the Wave Equation Method without prior approval of the Engineer and a revaluation of the driving system. The Engineer may modify the results from the Wave Equation Analysis, if he/she deems it necessary on the basis of information obtained from loading tests or dynamic field measurement.

The wave equation analysis will be performed by an engineer, registered with the Commonwealth of Massachusetts as a Professional Engineer and experienced in such work. The Contractor's engineer shall be experienced in the performance of the wave equation analysis and its function as related to pile capacity determination. The Contractor's engineer conducting the wave equation analysis shall be thoroughly familiar with the Geotechnical report for the project, the subsurface conditions at the site, and with the proposed foundation design.

The Contractor shall submit a written report with a summary of each wave equation analysis to the Department at least 2 weeks prior to pile driving. That submission shall include a copy of the entire "wave equation analysis program"

(WEAP) output in the form as specified in the above referenced FHWA Manual. The summary in the report will contain the plotted curves (3) of ultimate resistance vs. blowcount and compressive stresses vs. blowcount and tensile stresses vs. blowcount for each WEAP output for each embedded length and for several stroke-lengths if a variable stroke (diesel) hammer is used.

The Contractor's engineer conducting the wave equation analysis shall also be the same engineer to conduct the dynamic load tests with the PDA when the Contractor is required to perform such dynamic load tests.

940.62 Pile Load Tests.

A. General.

The piles to be tested shall be driven in accordance with the requirements under the item for the type of pile to be used on the project. These tests shall be made before driving production on piles.

Each pile to be tested shall be driven to the design load as determined by either the Formula in Section 940.61A or a Wave Equation Analysis in accordance with Section 940.61B and, at the discretion of the Engineer, by dynamic pile measurements in accordance with Section 940.62C.

B. Static Tests.

Static pile load tests shall be conducted in accordance with ASTM D 1143, "Standard Method of Testing Piles under Static Axial Compressive Load," except as modified herein.

1. General.

The top elevation of the test pile shall be determined immediately after driving and again just before load testing to check for heave. Any pile which heaves more than 5 millimeters shall be redriven or jacked to the original elevation prior to testing. Unless otherwise specified in the contract, a minimum 3 day waiting period shall be observed between the driving of any anchor piles or the load test pile and the commencement of the load test.

Tell-tales shall be installed in all test piles to determine the percent of the applied test load being transferred to the bearing stratum. Number and location of tell-tales shall be as shown on the plans.

The Department will furnish levels and the personnel necessary to make all evaluations. All measuring devices and gauges that will be required, other than levels, shall be furnished by the Contractor.

Readings of settlement and rebound shall be referred to a fixed benchmark and shall be made using at least two micrometer dial extensometers graduated to one-hundredth of a millimeter and located 90 degrees apart along the axis of the exposed portion of the pile. Readings shall be taken at intervals specified in Sections 4, 5, or 6, Test Procedures. Readings shall be taken from gauges mounted on a reference beam supported at each end by reliable supports located at least 3 meters from the center of the test pile.

In addition to these readings, elevations to the nearest one-half of a millimeter by use of an Engineer's level and rod shall be recorded. The entire measuring installation shall be protected from direct sunlight, frost action and other disturbances that might affect its reliability.

The head of each test pile shall be cut-off level or shall be capped in such a manner as to produce a plane, horizontal bearing surface.

All records obtained during the test shall be the property of the Department. Furnishing and driving the piles, complete in place, will be paid for under the item for the type of piles on which the test is made.

Before starting the work, the Contractor shall submit to the Engineer, for approval, a written description of the equipment and method which he/she intends to use. The method must be of an approved type and shall be altered as necessary to meet the approval of the Engineer.

2. Load Application.

The method of applying the load to the pile will be at the option of the Contractor, provided the method is adaptable to accurate measuring of the applied load, and the method avoids eccentric loading on the pile. The first increment of load shall include allowance for weight of the equipment. Hydraulic Jacks shall be of an approved type and capable of supplying a minimum jacking capacity equal to the maximum test load plus 20%. The Contractor shall provide a load cell, subject to the approval of the Engineer, which is capable of determining load transfer to the test pile. The load cell shall have a capacity equal to the jack capacity, and shall be calibrated by a certified testing laboratory. In addition, the Contractor shall provide a calibration certificate from a certified testing laboratory relating pressure gauge reading to jack load. The Contractor shall submit to the Engineer both calibration certificates prior to load testing.

3. Reaction Loads.

The total reaction load shall be not less than 250 percent of the design load for both the short duration and maintained load tests and 400 percent of the design load for the quick load test method.

Any one of the following devices for applying the vertical loads may be used:

a. *Load Supported Directly by Pile.* A loading platform or box shall be supported on top of the pile to be tested. The construction of the box and the application of the loads shall be such that no lateral forces will be applied to the top of the pile and no impact will occur as the loads are placed. In cases where the test pile is in an excavation below the natural ground surface, an extension column of structural steel or steel pile may be used to extend from pile head up to the test box.

b. *Load from Weighted Box or Platform Applied to Pile by Hydraulic Jack.* A test box or test platform resting on cribbing shall be constructed over the pile and loaded with suitable material. A hydraulic jack with a recently calibrated pressure gauge shall be interposed between the pile head and the load box and load applied to the pile by operating the jack.

c. *Load Applied to Pile by Hydraulic Jack Acting Against Anchored Reaction Members.* Two or more piles to be used as anchor piles shall be driven at a minimum distance of 1.5 meters from the test pile. A girder of sufficient strength to act as a reaction beam shall be fastened to the upper ends of the anchor piles. A hydraulic jack with a recently calibrated pressure gauge shall be interposed between the head of the test pile and the underside of the reaction beam and the test load applied to the pile by operating the jack.

d. *Test Procedures.* The Contractor shall use the load sequence specified under "Short Duration Load Test" unless otherwise directed by the Engineer or the Contract Documents to use the load sequence specified for "Quick Load Test" or "Maintained Load Test."

The application of the test load shall not begin sooner than 72 hours after placing concrete in Cast-in place and Steel pipe piles and no sooner than 48 hours after other type piles are driven.

A single pile shall be load-tested to not less than twice the design load. When two (2) or more piles are to be tested as a group, the total load shall be not less than one and one-half (1-1/2) times the design load for the group.

4. Short Duration Test.

The load sequence shall be as follows:

a. Apply 25% of the design load every one-half hour up to the greater of the following: two hundred percent (200%) of design load; to an applied load which transfers one hundred percent (100%) of design load to the bearing strata as determined from tell-tale measurements but not greater than 90% of the reaction load. Longer time increments may be used, but each time increment should be the same.

b. At the maximum applied load, maintain the load for a minimum of one hour and until the settlement (measured at the lowest point on the pile at which measurements are made) over a one-hour period is not greater than 0.25 millimeters.

c. Remove 25% of the applied load every 15 minutes until zero load is reached. Longer time increments may be used, but each should be the same.

d. Measure rebound at zero load for a minimum of one hour. In no case shall a load be changed if the rate of settlement is not decreasing with time. For each load increment or decrement, take readings at the top of the pile and on the internal instrumentation at 1, 2, 4, 8, and 15 minutes and at 15 minutes intervals thereafter.

Provided that the design load does not exceed one hundred percent (100%) of the load transferred to the bearing stratum at the maximum test load, the design load from this test type shall be the greater of the following:

a. Design Load Based on Settlement During Loading:

1. For Piles 610 millimeters or less in diameter:
   Fifty percent (50%) of the applied test load which cause a gross settlement at the pile cutoff grade equal to the sum of: a) the theoretical elastic compression of the pile in millimeters, assuming all the load on the butt is transmitted to the tip, plus b) 4 millimeters, plus c) one hundred twentieth of the pile tip diameter or pile width in millimeters, i.e.,

   $$S_f = S + (4 + D/120)$$

   Where:

   S_f = Settlement at failure in millimeters
   D = Pile diameter or width in millimeters
   S = Elastic deformation of pile length in millimeters

2. For Piles greater than 610 millimeters in diameter or width:

$S_f = S + D/30$

If the settlement are so small that the load-settlement curve does not intersect the failure criterion, the maximum test load shall be taken as the failure load.

b. Design Load Based on Net Settlement After Rebound:
Fifty percent (50%) of the applied test load which results in a net settlement of the top of the pile of 13 millimeters, after rebound for a minimum of one hour at zero load.

5. Maintained Load Test.

The test loads shall be applied in at least five increments equal to 50, 100, 150, 175 and 200 percent of the design load. All intermediate load steps shall be maintained constant for a period of two hours. During the loading cycle, the contemplated design load and twice the design load shall be maintained constant until settlement does not exceed 0.5 millimeters in 12 consecutive hours, or until the pile has failed as determined by the Engineer. The loading period for twice the design load shall be no less than 24 hours.

The total test load shall be removed in decrements not exceeding 1/4 of the total test load. Each step of unloading shall be maintained constant for a period of 4 hours.

During loading, record readings of time, load, and movement at intervals not exceeding 10 minutes during the first one-half (1/2) hour, 30 minute intervals up to two (2) hours at one (1) hour intervals up to 12 hours and 2 hour intervals thereafter.

During unloading, take readings at intervals not exceeding 20 minutes for the first hour and 1 hour intervals thereafter. Take a final rebound reading 4 hours after all load has been removed.

The design load shall be determined in accordance with the procedures specified in the Short Duration Load Test.

6. Quick Load Test.

This load test shall be performed on individual piles only.

The load shall be applied in increments of 50 to 100 kiloNewtons and shall not exceed 10% of the design load. The time interval between readings shall be 2-1/2 minutes or as otherwise specified. Add load increments until continuous jacking is required to maintain the test load or until the capacity of either the loading apparatus or reaction load is reached. Hold the failure load or maximum applied load for not less than five (5) minutes. Unload the pile in no less than four equal increments.

Record time, load, and movements immediately, before and after the application or removal of each load increment. Take a final rebound reading 15 minutes after removing all loads. The design load shall be determined in accordance with the procedures specified in the Short Duration Load Test.

C. Dynamic Load Tests.

1. Dynamic Load Test Preparation.

Dynamic measurements will be taken by the Engineer during driving piles designated as Dynamic Load Test (DLT) piles.

Prior to placement in the leads, the Contractor shall make each designated concrete and/or timber pile available for taking of wave speed measurements and for predrilling the required instrument attachment holes. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling. The Engineer shall furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. The instruments will be attached near the head of the pile with bolts placed in masonry anchors for the concrete piles or through drilled holes on the steel piles.

The Contractor shall provide the Engineer reasonable means of access to the pile for attaching instruments after the pile is placed in the leads. If, in the opinion of the Engineer, the instruments cannot be installed before pile is placed in the leads, then a platform with a minimum size of 1.2 meters x 1.2 meters designed to be raised to the top of the pile while the pile is located in the leads shall be provided by the Contractor. It is estimated that the Engineer will need approximately 1 hour per pile to install the dynamic load test equipment.

The Contractor shall furnish electric power for the dynamic load test equipment. The power supply at the outlet shall be 10 ampere, 115 volt, 55-60 hertz, A.C. only. Field generators used at the power source shall be equipped with functioning meters for monitoring voltage and frequency levels.

The Contractor shall furnish a shelter to protect the dynamic load test equipment from the elements. The shelter shall have a minimum floor size of 2.4 meters x 2.4 meters and minimum roof height of 2.1 meters. The inside

temperature of the shelter shall be maintained above 7 °C. The shelter shall be located within 15 meters of the test location.

The pile shall be driven to the depth at which the dynamic analyzer indicates that the ultimate pile resistance shown in the contract plans has been achieved unless directed otherwise by the Engineer.

The stresses in the piles will be monitored during driving with the dynamic analyzer to ensure that the pile stresses determined do not exceed the values which would cause pile damage. The point of impending damage in steel piles is defined herein as a compressive driving stress of 90% of the yield point of the pile material. For concrete piles, tensile stresses in units of kiloPascals shall not exceed 7.8 multiplied by the square root of the concrete compressive strength, f'_c in kiloPascals, plus the effective prestress value, $[7.8(f'_c)^{0.5}$ + prestress] and compressive stresses shall not exceed 85% of the compressive strength minus the effective prestress value (0.85 f'_c – prestress). For timber piles, the compressive driving stress shall not exceed three times the allowable static design strength listed on the plans. If necessary, the Contractor shall reduce the driving energy output of the hammer in order to maintain stresses below these values. If non-axial driving is indicated by the dynamic analyzer measurements, the Contractor shall immediately realign the driving system.

When directed by the Engineer, the Contractor shall wait 12 to 24 hours and then after the instruments are reattached, retap the dynamic load test pile. It is estimated that the Engineer will require approximately 1/2 hour to reattach the instruments. A cold hammer shall not be used for the redrive. The hammer shall be warmed up before redrive begins by applying at least 20 blows to another pile. The maximum amount of penetration required during redrive will be 150 millimeters or the maximum total number of hammer blows required will be 50, whichever occurs first. After retapping, the Engineer will either provide the cut-off elevation or specify additional pile penetration and testing.

2. Dynamic Load Test by Contractor.

When directed in the Contract documents, dynamic measurements will be taken by the Contractor during pile driving and shall be subject to the Department's field review. Those piles to be tested will be designated as dynamic load test piles or "DLT" on the plans and shall be located by the Department. Preliminary location of the piles to be tested are subject to revision by the Engineer. The piles to be static load tested and approximately 10% of the remaining driven piles will be tested by this method unless otherwise directed by the Engineer.

The dynamic tests are to be made by the Contractor's engineer who shall be registered with the Commonwealth of Massachusetts as a Professional Engineer. The same Contractor's engineer conducting the wave equation analysis shall perform the dynamic load tests. Each dynamic test shall also include a "CAP-WAP" analysis in order to closely model actual field conditions. The damping, quake and soil resistance distribution values will be provided by the Contractor's engineer. The Contractor's engineer shall be experienced in the use of the Pile Driving Analyzer (PDA) and its purpose as related to pile capability determination. The Contractor's engineer will also be proficient in the interpretation of the PDA and "CAP-WAP" data and shall determine the tested pile's capacity based upon this data.

The Contractor shall submit to the Department a written report with a summary of results upon completion of each PDA test including "CAP-WAP" analysis. A copy of the entire PDA and "CAP-WAP" analysis output will be submitted to the Department for review along with the Contractor's report of each PDA and "CAP-WAP" test. The PDA and "CAP-WAP" output will *not* substitute for a written report which includes a summary of the results, but will be submitted *with* such a report.

The Contractor shall submit evidence of the engineer's proficiency to the Department at least 2 weeks in advance of the work to allow the Department adequate time for review and approval or comments. No pile driving will be allowed until written approval has been received from the Engineer.

a. PDA Equipment.

The equipment to perform the dynamic tests shall be a Model GC pile driving analyzer by Globe, Rausche, Likins and Associates, Inc., 4423 Emery Industrial Parkway, Cleveland, Ohio 44128, telephone (216) 831-6131, or approved equal. The equipment shall be complete with all pertinent peripheral equipment necessary to complete and record the test data and complete the analysis of pile capacity.

b. Pile Testing Program.

At least 2 weeks prior to initiating the pile driving operation, the Contractor shall submit a "pile testing program" outline to the Department for review and approval. The following procedure is suggested as an example of a pile testing program which incorporates the wave equation analysis and the dynamic pile driving analysis including the "CAP-WAP" portion of the dynamic testing.

The testing should be performed by experienced engineers. The scope and sequence of testing services is suggested as follows:

1. Perform initial wave equation analysis based on subsurface conditions, pile type, pile capacity, and pile driving equipment to be utilized. See the previously referenced FHWA Manual for examples of the WEAP analysis procedure from static analysis to parameter selection. Submit written report of each wave equation analysis with complete print-out to the Department for review.

2. Drive piles to be static load tested first at locations specified on the plans using the driving criteria established by the wave equation. The driving criteria, however, is subject to change due to actual hammer performance and expected soil strength changes. Dynamic testing with the PDA shall be made during the driving of all piles to be static load tested.

3. After performing dynamic load testing on the piles to be static load tested, evaluate static load test piles after a minimum waiting period, to be determined by the Engineer, by restriking the piles with simultaneous dynamic testing by the PDA. Restrike testing is considered essential for service load capacity determinations if they are to include setup/relaxation effects since the analyzer gives the pile capacity at the time of testing.

4. The remaining 10% of the piles at each substructure which have been designated for PDA testing should be tested during additional construction control visits. They should be tested on initial installation and restrike, as soil conditions dictate at the discretion of the Engineer. Other than these tests, the Engineer will determine if further dynamic tests should be made when the hammer system is replaced or modified, etc.

5. Perform supplementary, rigorous laboratory wave analysis of the measured data using "CAP-WAP" on all of the piles tested to verify and refine field results, and upon restrike testing.

6. Submit to the Department a written report including a written summary of results in addition to a copy of the actual print-outs. This report will show all pertinent information, upon completion of the PDA testing and "CAP-WAP" analysis of each pile.

7. Based on field results, the following will be reviewed, analyzed and the results of this analysis will be printed in a report by the Contractor's Engineer.

   a. Driving stresses (compression or tension)
   b. Hammer system efficiency
   c. Pile structural damage/integrity
   d. Bearing capacity

8. It should be recognized that each site has unique and often unforeseen characteristics. Judgments are to be made, even during the testing program by the Contractor's experienced engineer performing the test as to deletions or additions to a "standard" program which will result in the most benefit to the foundation design.

940.63 Test Piles (Indicator Piles).

Test piles shall be driven when shown on the plans at the locations and to the lengths specified by the Engineer. All test piles shall be driven with impact hammers unless specifically stated otherwise on the plans. In general, the specified length of test piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions. The driving equipment used for driving test piles shall be identical to that which the Contractor proposes to use on the production piling. Approval of driving equipment shall conform with the requirements of these specifications. The Contractor shall excavate the ground at each test pile to the elevation of the bottom of the footing before the pile is driven.

In the absence of a wave equation analysis, test piles shall be driven to a penetration of 10 millimeters or less after 10 consecutive hammer blows unless the Engineer provides a hammer blow count established by wave equation analysis within a range of tip elevations or unless the driving criteria is established by the dynamic formula.

Test piles which do not attain the bearing value specified above at a depth of 300 millimeters above the estimated tip elevation shown on the plans shall be allowed to "set up" for 12 to 24 hours as directed by the Engineer before being redriven. A cold hammer shall not be used for redrive. The hammer shall be warmed up before driving by applying at least 20 blows to another pile. If the bearing value is not attained on redriving, the Engineer may direct the Contractor to drive a portion or all of the remaining test pile length and repeat the "set up" redrive procedure. Test piles driven to plan grade and not having the bearing required shall be spliced and driven until the required bearing is obtained.

A record of driving of test piles will be prepared by the Contractor which includes the number of hammer blows per meter for the entire driven length, the as driven length of test pile, cutoff elevation, penetration in ground, and any other pertinent information requested by the Engineer. The Contractor shall provide the information listed in the "Pile Driving and Equipment Form" to the Engineer for inclusion in the record. If redrive is necessary the Engineer shall record the number of hammer blows per 20 millimeters of pile movement for the first 300 millimeters of redrive. The Contractor

shall not order piling to be used in the permanent structure until test pile data has been reviewed and pile lengths are authorized by the Engineer.

940.64 Determinations of Required Pile Driving Resistance and Depth of Penetration.

Practical Refusal.

Unless otherwise specified practical refusal will be considered attained when ten blows of an adequate hammer, operating at the number of blows per minute for which the hammer is rated by the manufacturer, are required to produce a total penetration of 10 millimeters. Driving should then cease, provided that the pile has not hit an obstruction and has been driven to the depth at which the borings indicate refusal material or bedrock.

When pile are not either required or directed to be driven to bedrock or refusal, the Engineer shall determine the required driving resistance for safe bearing values and shall establish minimum tip elevations or acceptable bearing stratum depending on subsurface condition. The required driving resistance will be established as described in Section 940.61.

When determining the final driving resistance of the pile, the hammer shall be operated at a speed not less than ninety percent (90%) of the maximum blows per minute specified by the manufacturer. The final driving resistance shall be appropriately adjusted to the actual hammer energy delivered as specified by the manufacturer for the operating speed.

When directed by the Engineer, the Contractor shall make dynamic field measurements to demonstrate that the percentage of the hammer's rated energy transferred to the pile head.

940.65 Procedure for Driving.

A. General.

No piles shall be driven except in the presence of the Engineer. Where practicable, piles shall be driven continuously to the required penetration and bearing capacity. When the continuous installation of a pile has been stopped for any reason, the pile advancement shall be started in a manner which will not damage the pile. Any pile which cannot be advanced or which is damaged in the process shall be rejected and either cut-off and repaired or replaced at the discretion of the Engineer. Rejected piles shall be replaced or repaired at no cost to the Department. Unless specified otherwise by the Engineer, any pile restarted shall be advanced no less than 75 millimeters before determining the final driving resistance.

The order of placing individual piles in pile groups shall be either starting from the center of the group and proceeding outwards in both directions or starting at the outside row and proceeding progressively across the group.

If any driven pile is raised more than 10 millimeters by the subsequent driving of adjacent piles, it shall be redriven to the required final resistance to penetration with no compensation for the additional driving.

Cast-in-place and steel pipe piles shall not be filled with concrete until all piles within a footing have been checked for uplift and redriven where necessary unless otherwise directed by the Engineer.

All piles shall be driven a minimum of 3 meters into original ground unless otherwise directed by the Engineer.

B. Accuracy of Driving.

The tops of piles at cut-off elevation shall be within 150 millimeters of plan locations. Furthermore, the as-driven center of gravity of any pile group at cut-off elevation shall be within 5% of the plan location of the center of gravity. No pile shall be nearer than 100 millimeters from any edge of the cap. Any increase in size of cap to meet this edge distance requirement shall be at the Contractor's expense.

Piles shall be installed so that the axial alignment of the top 3 meters of the pile is within 4% of the specified alignment. For piles that cannot be inspected internally after installation, an alignment check shall be made before installing the last 1.5 meters of pile or after installation is completed provided the exposed portion of the pile is not less than 1.5 meters in length. The Engineer may require that driving be stopped in order to check the pile alignment. If the location and/or alignment tolerances specified are exceeded, the extent of overloading shall be investigated and if, in the judgment of the Engineer, corrective measures are necessary, suitable measures shall be designed and constructed by the Contractor at no cost to the Department. Pulling laterally on piles to correct misalignment shall not be permitted.

C. Obstruction.

If conditions during driving indicate that the pile is hitting an obstruction and the obstruction is not in embankment that has been placed under the contract the following shall apply:

1. If the elevation of the top of the obstruction is less than 1.5 meters below the elevation of the bottom of the footing, the Contractor shall drive through the obstruction or shall use whatever means are necessary to remove or circumvent the obstruction without any additional compensation.

2. If the elevation at the top of the obstruction is 1.5 meters or more below the elevation of the bottom of the footing, the Contractor shall use a combination of water jet and hammer to drive through the obstruction without any additional compensation.

3. If the use of the combination water jet and hammer (2) above does not allow pile to be driven through the obstruction, upon approval by the Engineer, the Contractor shall exercise one of the following options; (a) Drive all surrounding and adjacent piles to the hand-up pile or piles to determine the approximate size of the obstruction, (b) Employ the services of a test boring or other such exploratory method.

4. After the approximate size of the obstruction is obtained, the Engineer will determine whether the obstruction is to be removed or if the footing will be redesigned leaving the obstruction in place.

5. If it is determined that the obstruction (3) above is to be removed, the Contractor shall be paid for the work of removing the obstruction under Subsection 9.03.

6. If the footing is redesigned any additional piles or excavation required shall be paid at contract unit prices. Any change in concrete or steel reinforcement shall be paid as specified under Subsection 995.80.

7. No allowance of any kind other than (5) and (6) above and as provided in Subsection 8.09 will be allowed for the above.

940.66 Splices.

A. General.

Full length piles shall always be used where practical.

B. Timber Piles.

Splicing of timber piles will not be permitted.

C. Steel Pipe Piles and Steel H Piles.

Where these piles have to be extended, the spliced connection shall be a continuous full penetration butt-weld. The butt-welding shall be made to develop the full strength of the pile, both in bearing and in bending. Welding shall conform to the applicable provisions of Subsection 960.61.

Butt-weld splicing of piles other than as shown on the plans will not be permitted without the express written consent of the Engineer.

Welded splice connections for pipe piles shall be made with a welding or backup ring. Preheat requirements for the welding of pipe piles shall be as specified for ASTM A 36 steel.

D. Precast-Prestressed Concrete Piles.

Splices shall develop one hundred percent (100%) of the pile strength both in direct stress and in bending. Splices for concrete piles shall be made by the cement-dowel method. Details of the cement-dowel splice shall be shown in the plans. Mechanical splices for concrete or steel piles may be approved by the Engineer if the splice can transfer the full pile strength in compression, tension and bending. Piles shall have only one (1) splice per pile. Splices in the lower 12 meters of the pile will not be permitted.

940.67 Defective Piles.

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse, producing: injurious splitting, splintering and brooming of the wood; deformation of steel; breakage and cracking in precast-prestressed concrete piles.

Manipulation of piles to force them into proper position will not be permitted when considered to be excessive by the Engineer. Piles damaged by reason of internal defects, by improper handling, driving, defective welds or piles driven out of proper location, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the piles in question.

1. The pile shall be withdrawn and replaced by a new and if necessary, a longer pile.
2. A second pile shall be driven adjacent to the defective or low pile.

Damaged steel piles may be spliced at some point such that the completed pile shall be satisfactory.

After the shells for cast-in-place piles and pipe for pipe piles have been driven, they shall be inspected and will be classified defective if any of the following are discovered:

1. The casing shows signs of buckling.
2. The diameter varies more than 15 percent from the original value.
3. The point of the casing deviates more than 10% of the length of the pile below plan cut-off elevation from the design alignment.

4. The casing deviates more than 6% of its length from a straight line connecting the mid-points of the ends of the casing. This requirement shall be taken as satisfied if some segment of the bottom of the casing is visible. If the bottom of the casing is out of sight, the shape and alignment of the casing shall be surveyed with a suitable instrument supplied by the Contractor and approved by the Engineer.

5. The inside of the casing shows any signs of water or soil.

The Contractor shall provide sufficient lights and other equipment necessary to inspect each shell throughout its length.

Precast-prestressed concrete piles which break within 3 meters from the ground surface shall be, at the discretion of the Engineer, either replaced or cut-off and spliced at no cost to the Department. Piles which break below 3 meters from the ground surface shall be rejected and replaced by the Contractor at no cost to the Department. The Engineer may elect to use dynamic measurements to aid in evaluating pile integrity.

940.68 Cutoffs.

A. Timber Piles.

The tops of piles shall be sawed off to a true plane at the grades shown on the plans. All cuts and abrasions on treated piles shall be repaired in accordance with AWPA Standard M4.

Nail holes shall be filled by driving galvanized nails flush with the surface of the pile.

B. Steel or Cast-In-Place Piles.

After driving has been completed the steel or cast-in-place piles shall be cut off at the directed grade. Cutting of piles shall not be done until it is certain that further operations will have no effect on the previously driven piles.

Temporary capping devices shall be provided for cast-in-place and steel pipe piles immediately upon cut-off to prevent soil and water from entering driven piles prior to placing concrete.

C. Precast-Prestressed Concrete Piles.

Precast-prestressed concrete piles shall be cut-off at the grades specified on the plans or contract documents. Piles shall not be cut-off until it is certain that further pile driving operations will have no effect on the driven piles.

940.69 Placing and Protecting Concrete Filled Piles.

No concrete shall be placed in a shell or pipe until all piles within a footing have been satisfactorily driven, inspected and approved by the Engineer. No concrete shall be placed except in the presence of the Engineer.

Prior to placing concrete in each pile, 0.03 cubic meter of mortar, having a slump of not more than 75 millimeters, shall be deposited in the bottom of the pile.

Concrete shall then be deposited in the casing through a funnel having a neck not more than 450 millimeters long and not more than 180 millimeters in diameter. The funnel shall be provided with supports at the neck to permit air to escape during the concrete placing operation.

Placing of concrete in each pile shall be continuous and in a manner which will assure complete filling of the casing. The slump of the concrete shall be from 75 to 130 millimeters.

Special care shall be exercised in filling the casing to prevent honeycomb and air pockets from forming. Internal vibrators and other means shall be used to the maximum depth practicable, as determined by the Engineer, to consolidate the concrete.

During cold weather the pile heads and surrounding ground shall be covered by straw or other suitable protection to prevent frost from damaging the concrete itself or heaving the ground.

During hot weather pile heads shall be protected by suitable covering material.

COMPENSATION

940.80 Method of Measurement.

The length of piles to be paid for shall be the total length in place, measured from the tip of the pile to the plane of the plan cut-off elevation.

Timber pile cut-offs will be measured by the meter and the length to be paid for will be the difference between the length of piles approved by the Engineer on the schedule submitted by the Contractor and the length of piles in place, but will not include any lengths cut-off for correction of damaged ends or for piles rejected by the Engineer.

Precast-prestressed piles will be measured by the meter from the tip of the pile including any steel extension installed for protection (to the plan cut-off elevation) and any extensions required to reach the cut-off elevation.

940.81 Basis of Payment.

Timber piles will be paid for at the contract unit price per meter under the item for Untreated Timber Piles, left in place, or under the item of Treated Timber Pile, left in place.

If timber piles furnished according to the approved schedule of length prove inadequate to sustain the required load, the Engineer may in writing make changes in the schedule previously approved by him/her and the piles ordered and driven according to the revised schedule will be paid for at the contract unit price per meter.

If as a result of the revised schedule or as a result of timber pile cut-off being used as piles, any of the timber piles which have been purchased by the Contractor in accordance with the approved schedule cannot be used elsewhere on the project, such piles not used will be paid for under the provisions of Subsection 9.03, except that no profit or overhead will be allowed and subject to an allowance for their fair salvage value of the piles. In no case will payment for these piles exceed 50% of the bid price per meter of either treated timber piles or untreated timber piles.

Payment for cut-off allowance on treated and untreated timber piles will be made at 50% of the respective bid price per meter. The cut-off shall become the Contractor's property.

Timber test piles, whether used in the structure or driven outside the structure, will be paid for at the contract unit price for each pile driven under the item for Timber Test Pile. When the test pile is not used in the structure, the price shall also include full compensation for the removal of the test pile, or cutting off 1 meter below finished grade of ground and backfilling the hole with suitable material.

Steel piles will be paid for at the contract unit price per meter under the item for Steel Piles, complete in place.

Cast-in-place concrete and steel pipe piles will be paid for at the contract unit price per meter under the items Cast-in-Place Concrete Piles and Steel Pipe Piles, complete in place, including the concrete and steel reinforced cement.

Piles driven as Test Piles or for Load Tests, if incorporated in structures, will be paid for at the contract unit price for the length in place under the item for the type of pile.

No payment will be made for the cut-off of precast-prestressed concrete or steel piles.

Pile shoes will be paid per each on piles accepted for payment by the Engineer.

All costs for splicing piles shall be included in the contract unit price per meter for the respective pile item, which price shall also include full compensation for delays incurred by splicing of piles or by any other operations in connection with the work on piles.

Pile loading tests will be paid for at the contract unit price for each pile tested under the item for a specific load sequence.

The contract price shall also include full compensation for any interruptions to pile driving or other operations in the vicinity of the pile loading tests. The test at each pile shall be considered completed when all materials and equipment used in the test have been removed.

If a pile load test is applied to a steel pipe pile, cast-in-place concrete pile, or precast-prestressed concrete pile, then the contract price for a load test shall also include full compensation for cutting the pile to the grade necessary to properly incorporate the pile in the structure or, if it is not to be incorporated in the structure, for cutting the pile to the grade necessary to avoid its interference with the proposed construction.

The cost of performing Wave Equation Analysis shall be included in the contract unit price per meter of pile.

Payment for initial and restrike dynamic pile measurements will be at the contract unit price per pile tested. The price shall include costs for all sensory and wiring devices, monitoring equipment; the setting up and checking of equipment, monitoring personnel; costs associated with Contractor's down time during regular working hours while setting-up equipment and making dynamic measurements.

940.82 Payment Items.

940.	Untreated Timber Piles	Meter
941.	Treated Timber Piles	Meter
942.*	Steel Pile, HP ___ x ___	Meter
943.*	Steel Pipe Pile ___ millimeters OD	Meter
945.	Cast-in-Place Concrete Piles	Meter
946.	Precast-Prestressed Concrete Pile	Meter

947.1	Timber Test Pile		Each
948.1	Short Duration Load Test		Each
948.2	Maintained Load Test		Each
948.3	Quick Load Test		Each
948.4	Dynamic Load Test Preparation		Each
948.41	Dynamic Load Test by Contractor	Each	
948.5	Pile Shoes		Each
999.940	Untreated Timber Pile Cut-off		Meter
999.941	Treated Timber Pile Cut-off		Meter

*Designation by size and mass.

SECTION 950

SHEETING

DESCRIPTION

950.20 General.

This work shall consist of furnishing and placing lumber, wood or steel sheeting of the kinds and dimensions required, complying with these specifications, where indicated on the plans or where directed. All dimensions specified for lumber are nominal dimensions.

MATERIALS

950.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III. Materials:

Lumber Sheeting	M9.05.0
Wood Sheeting	M9.05.0
Steel Sheeting	M8.05.4

CONSTRUCTION METHODS

950.60 General.

Work shall not be started until all materials and equipment necessary for their construction are either on the site of the work or satisfactorily available for immediate use as required. Sufficient labor and equipment shall be employed to insure the completion of the excavation, placing of the concrete and backfilling in the shortest possible time.

Where no other direction is given, sheeting shall be driven to such depth that the footing may be lowered at least 500 millimeters below the elevation shown on the plans without any change in the sheeting as driven.

Sheeting that is to be paid as sheeting left in place shall be driven to a minimum depth of 1.5 meters below the proposed bottom of the concrete footings unless otherwise directed. After sufficient progress has been made on the construction the sheeting shall be cut off at the tops of the footings or as otherwise directed.

950.61 Placing of Sheeting.

The sheeting shall be securely and satisfactorily braced to withstand all pressures to which it may be subjected and be sufficiently tight to prevent any flow of water or material into the space in which concrete is deposited. The bottom